AN INDUSTRY SURVEY OF PRODUCTION RATES FOR SUBSTRUCTURE WORKS

FARIZ BIN ADNAN

CIVIL ENGINEERING
UNIVERSITI TEKNOLOGI PETRONAS
JUNE 2010

An Industry Survey of Production Rates for Substructure Works

by

Fariz Bin Adnan

Dissertation submitted in partial fulfillment of

The requirements for the

Bachelor of Engineering (Hons)

(Civil Engineering)

JUNE 2010

Universiti Teknologi PETRONAS

Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

An Industry Survey of Production Rates for Substructure Works

By

Fariz bin Adnan

A project dissertation submitted to the

Civil Engineering Programme

Universiti Teknologi PETRONAS

in partial fulfilment of the requirement for the

BACHELOR OF ENGINEERING (Hons)

(CIVIL ENGINEERING)

Approved by,

(Assoc. Prof. Ir. Dr. Arazi Idrus)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

June 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

FARIZ BIN ADNAN

ABSTRACT

Productivity is an important indicator for measuring construction output. The information on productivity is important for estimating and scheduling a construction project. This study attempts to study on the production rate values for substructure works. For this research, sample survey method will be use and the questionnaire will be distribute to 300 contractors through Construction Industry Development Board (CIDB) Malaysia ranging from G5 class to G7 class contractors. The questionnaire will be divided into 4 sections where by the respondent needs to answer all the required questions. After that, the questionnaire from the contractors will be compile together and do some analysis on the production rate for certain activities listed for substructure works. This is the activity where by the author needs to determine the typical production rate and in the end, the author needs to develop a database of substructure works for productivity rate.

ACKNOWLEDGEMENT

Praise is to the Almighty Allah the God of the Universe who gave me Strength to face all challenges in this world. This piece of work would never becoming true without the contributions from many people and also the organizations. I would like to acknowledge each and every person who has contributed their effort in this study by whatever means directly or indirectly.

First of all, I would like to acknowledge my supervisor, Assoc. Prof. Ir. Dr. Arazi Idrus for his kind assistance and advice throughout this study and also not forgetting to the post graduate Mr Saiful and Sana who also helping in my works. Special thanks to the respondents of this study that I had interviewed, called and even email asking for help in improving my questionnaire survey form and also achieving the data. Thank you for their precious comments and ideas that have provided me with more useful data and information. Not forgetting to the contractors for spending their valuable time answering the questionnaire. Your kind and generous help will always be in my mind and I will never forget until the end of my life.

Thanks go to my family as well especially to my beloved father and mother, Mr. Adnan Ghazali and Mrs. Halina Harun. Not to forget, to all my friends from whom I have received a great deal of support while conducting this study at UTP. For the rest of the persons who I didn't mention here, who have participated in various ways to ensure my research succeeded, thank you to all of you.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURE

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Productivity is extremely important in construction industry. In construction industry nowadays, there are many factors influence the productivity rate. Some factor that create a variation in production rate is hard to control. But, some factor can be easily be identified and modified and can leads to the improvement of the productivity rate. Frederick W.Taylor`s has conducted some research in optimizing worker performance during the early 1900s. By analyzing the research, using stop watch studies the efforts of a worker to load pig iron onto a railroad car, taylor was able to show how the daily output per worker could be increased. Due to research done by . Frederick W.Taylor`s leads to other people who develop new technique. Thomas and Sanvido 1989 had made an analyzed that variation in production rate due to inefficient material management

1.2 Problem Statement

Malaysia is one of the develop country and the construction is still moving on. In the world of construction today, there is no specific production rate that can be implement by the Site people in order to achieve the most optimum of works. Regardless to the engineer whose already having experience in construction for more than 5 years, they know the rates that needs to be use but not all are appropriate. This production rate database is design to ease the new graduate student to know the production rate for certain items. Since they do not have experience in working field, this is the best guidelines for them.

Despite that, there are still some projects in Malaysia which are not completed in time and this problem is due to several factors that needs to do some research. For example like a project of 5 storey quarters building at Jalan Dato` Menteri, Johor should be completed on 7th April 2003 but the project was delay and finish on Jun 2004 due to some factor. In the context of Substructure works, one of the factor affect the completion project is the production rate. Information like activity duration plays an important in scheduling construction activities in site. Activity duration can be express by:

Production Rate(P)= Quantity of Work(Q)/Activity Duration(T)

Usually production rate is affected by controlled and uncontrolled factor which are no specific calculation involved. They are based on the experience of a construction engineer and also previous company experience. By implementing this survey of production rate by following the methodology listed and analyzed carefully, the industry can use a typical production rate which can be accessible by everyone in the industries.

1.3 Objective(s)

The objectives is to make a survey of production rate values especially in substructure works. In details, the research involves as listed below:

i. To collect data on production rates from the industries.
ii. To analyze data collected using statistics.
iii. To develop a database of substructure works production rates works.

1.4 Scope of Studies and Limitation

This study is mainly focused on the production rate in the construction industry. For this research, every work items needs to be under limitation or scope so that the analysis can be done easily. The research will be conducted in some project from East Coast peninsular Malaysia and some in West Coast peninsular Malaysia. Regarding for contractor class, the research will be conduct towards construction companies which are already registered with Construction Industry Development Board (CIDB) Malaysia and also by visiting the company. Since that the range of scopes are very huge, the scope of study will be limited to:

i. G5 to G7 class contractors registered with CIDB Malaysia.

ii. Contractors involved in building and road construction.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter summarizes the literature review on the research of production rates and factor involved in different of productivity in construction and infrastructure works of the available project reported before.

2.2 Definition of Productivity, Factors effecting productivity and Productivity identification

Production rate can be defined as different understanding depends on the parties involved. By definition, productivity is the ratio of the quantity input to the quantity of output.

Production Rate(P)= Quantity of Work(Q)/Activity Duration(T)

Dozzi and AbouRizk 1993 stated that for detailed estimating and project scheduling, productivity is measured at an activity level, and because construction activities are normally labor intensive, productivity at the activity level is referred to as labor productivity whereby quantity input as labor hours and output is called quantities. Other words, productivity is measured by labor hours per unit of works with other resources used such as equipment and overhead cost.

In construction industry, productivity is measured depends on different level for different purpose. The recently way to estimate the productivity are relying on estimator`s personal judgement, published productivity data, and historical project data.

There are many factors that contribute to productivity rate in the construction industry. Some factors that create variations in production rate for certain activities are extremely difficult to control. Frederick W.Taylor`s already done a preliminary research in optimizing worker performance during the early 1900s. Taylor already did the research that has been conducted in 1911 at Midvale Steel Inc in Pennsylvania (Robbins 1986). By analyzing with stopwatch studies the effort of a worker to load pig iron onto a railroad car, Taylor was able to show how the daily output per worker could be increased. Sub Structure is Basic framework or foundation that supports a superstructure, and is supported by an infrastructure.

Material delay, management constraints and adverse weather conditions are a few factors that can affect the progress on an activity. To calculate the production rate, Christian and Hachey(1992) proposed the method to calculate the production rate. This kind of method use video recording and stop watch to monitor the activities. Before the activity can be analyzed, it was divided into four categories. (1)Effective;(2)essential contributory;(3)waiting, (4) idle. Effective works positively influence the progress of the activity and work that has indirect but has positive influence on progress, like movement of material for important purposes is considered essential contributory. Idle time represents a category in which the worker is not working, But, if a worker unable to perform a task because external delay, such as late concrete delivery, the lost time considered as waiting time. Refer to **Table 1** for the sample of production rate measured at various project site.

Table 2.1: Sample of Production Rates Measured

Location/Site	Crew size (persons)	Method of placement	Volume concrete placed(m^3)	Activity duration (min)	Delay(min)	Production rate (m^3/person-h)	
						Average	Modified
1B	3	Chute	5	75	20	1.33	1.82
2A	3	Chute	7.8	73	46	2.14	5.78
3A	4	Chute	4	43	15	1.40	2.14
4A	4	Chute	5	57	9	1.31	1.56
5A	4	Chute	5.5	105	49	0.79	1.47
6C	4	Chute	12	94	6	1.91	2.06
7C	4	Chute	16	140	5	1.71	1.78
8A	5	Pump	19	124	28	1.84	2.37
9A	5	Pump	32	154	50	2.49	3.69

Published productivity data only presenting industry average rates. Even contractor use their own productivity standard base on their company`s average past performance and serves only as broad guideline for its estimator. Estimators` experience with the construction process and careful evaluation of productivity-influencing factors are important to identify the best productivity rate. However, this was dependant upon personal judgement is limited by the level of knowledge and experienced of a particular case and may not produce consistent and reliable project plans. Therefore a number of technique have been introduce to study the relationship between influencing factor versus productivity. Those technique are follows:-

- Smith 1999- Regression-based models were used to study earthmoving productivity.
- Sander and Thomas 1993- Regression models base on masonry productivity.
- Fayek and Oduba(2005)- Applied fuzzy expert system to predict productivity of pipe rigging and welding.

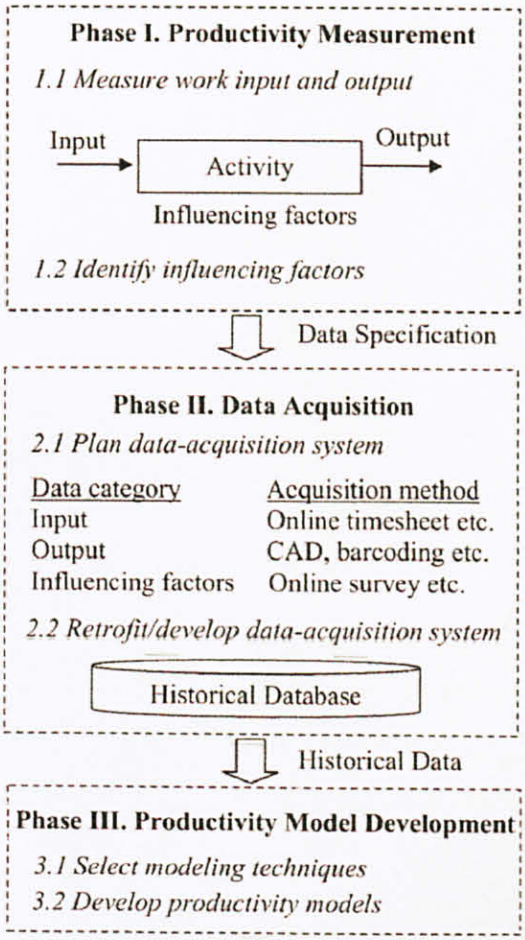

Figure 2.1: Framework for productivity modeling using historical data

Fig. 1 shows the framework productivity used. The framework contains three main stages which are productivity measurement, data acquisition, and productivity model development. The research target is to improve the current understanding of productivity measurement, data collection, and the selection and development of advanced models for productivity estimating. As shown in **Table 2**, the tables shows the productivity –Influencing factor for steel drifting. Altogether, there are total of 17 factors were identified. Simaan M. AbouRizk stated that during the productivity measurement stage, fundamental decisions are made regarding how productivity will be measured, the level of detail at which it would be measured. Also, the factor affect the productivity are also determined. For this project, steel drafting productivity is measured by hour per drafting and for the individual productivity fabrication activity is directly measured by time consumed to process each steel piece.

Table 2.2: Factors Affecting Labor Productivity _Reprinted with [Permission, CII _2006a]

Supervisor direction

- Inadequate instruction provided
- Not receiving directions due to size of the project
- Receiving compliments for doing a good job
- Being notified of mistakes when they occur
- Lack of goals for craft workers

Communication

- Different languages spoken on a project
- Disregard of crafts' productivity improvement suggestion
- Lack of "Big Picture" view on behalf of the crafts
- Craft worker importance
- Lack of communication among site management

Safety

- Shortage of personal protective equipment
- Lack of site safety resources

Tools and Consumables

- Availability of consumables
- Restrictive project policy on consumables
- Availability of hand tools
- Availability of power tools
- Lack of power source for tools
- Lack of extension cords
- Inexperienced tool room attendants
- Misplaced tools

Materials

- Availability of material
- Poor material quality
- Availability of bulk commodities
- Errors in prefabricated material
- Difficulty in tracking material

Engineering drawing management

- Drawing errors
- Availability of drawings
- Slow response to questions with drawings
- Drawing legibility
- Needed information not on drawings

Labor

- Availability of skill training
- Jobsite orientation program
- Availability of health and safety training
- Qualified craftsmen
- Craftsmen's pride in their work
- Craftsmen's incentive
- Motivated craft workers
- Equal pay on projects in a geographic area
- Craft workers' trust in supervisors

Foreman

- Foremen people skill
- Qualified foremen
- Fair/just performance reviews
- Foremen allowing crafts to work autonomously
- Lack of construction knowledge on behalf of foreman

Work and site management related factors affecting the labour productivity are also presented on 'daily observation' and 'observation' sheets (see Figure 1, Figure 3 and Table 2).

Work item	Work related productivity factor
Concrete pouring	The location of the work, weather conditions, the capacity and the number of the transmixers used, the transportation system of the ready mixed con-crete(dry/wet), the power of the pump or the capacity of the crane buckets, the distance between the concrete plant and the construction site
Formwork	The location of the work, weather conditions ,the type of the foundation or the type of the slab, the slab area or the floor height, the type of the form-work (plywood/timber/steel), the type of the scaf-folding (steel/timber)
Steel work	The location of the work, weather conditions, the type of the foundation or the type of the slab, the form of the steel when it arrived to the site (cut/uncut/bent), the size of the steel used, the type of the equipment used (bending machine/cutting machine)
Masonry work	The location of the work, weather conditions, the thickness and the height of the wall, the type of the wall elements (brick/block/lightweight block), the size of the wall elements

Table 2.3-Work related productivity factors included in the model.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This section will explains the methods for conducting the research, the type of data sample required and the technique that will be apply to collect the data.

3.2 Research Methodology

For the research, the author will use survey research methodology and will comprise of these following steps. The survey research methodology will be use for this study and will consist of these following steps:

Step One

Several literature review of the available work were recorded on Production rate values for substructure works . The literature review will include recent and past study of the project involved. The literature source will coming from books, journals and resources available in University Teknologi PETRONAS Resource Centre and also from online resources.

Step Two

Research on definition and seek information of the types of substructure works which had completed related to production rate. For this kind of research, work items involved and also scope of research should be included.

Step Three

Design of questionnaire based on the work activity involved in substructure works with the scope of works.

Step Four

Sending the questionnaire to construction companies in Malaysia based on the list from Construction Industry Development Board (CIDB) Malaysia.

Step Five

Conduct interview for selected companies to obtain more information about the survey

Step Six

Collection and compilation of the data from the survey research.

Step Seven

The collected data will be analyzed.

Step Eight

The result of the analyzed data will be summarized and ready to be presented.

Step Nine

Conclusion about the research, recommendation and any suggestion for further research.

3.3 Design of Questionnaire

There are three sections inside the questionnaire. The first section will provide general information about the construction contractor such as company's name and main business, class of the contractor, company`s experience in construction. The respondent need to address on their designation with the company and also respondent`s experience in building construction.

The second section will consist of three works activity under Sub-Structure that required the respondent to give several answers on quantity, unit used and also production rate for every activity listed. Under Data, the respondent need to fill in the value of total work day, No of workers per day and Machineries used per day. In this survey, The third section is Additional Information that the respondent need to add or giving comments about this project. This is to ensure that the author will have the feedback regarding the project whether or not the company have better ways to make this reasearch more successful.

3.4 Layout of the Questionnaire

The layout of the questionnaire is shown in figure

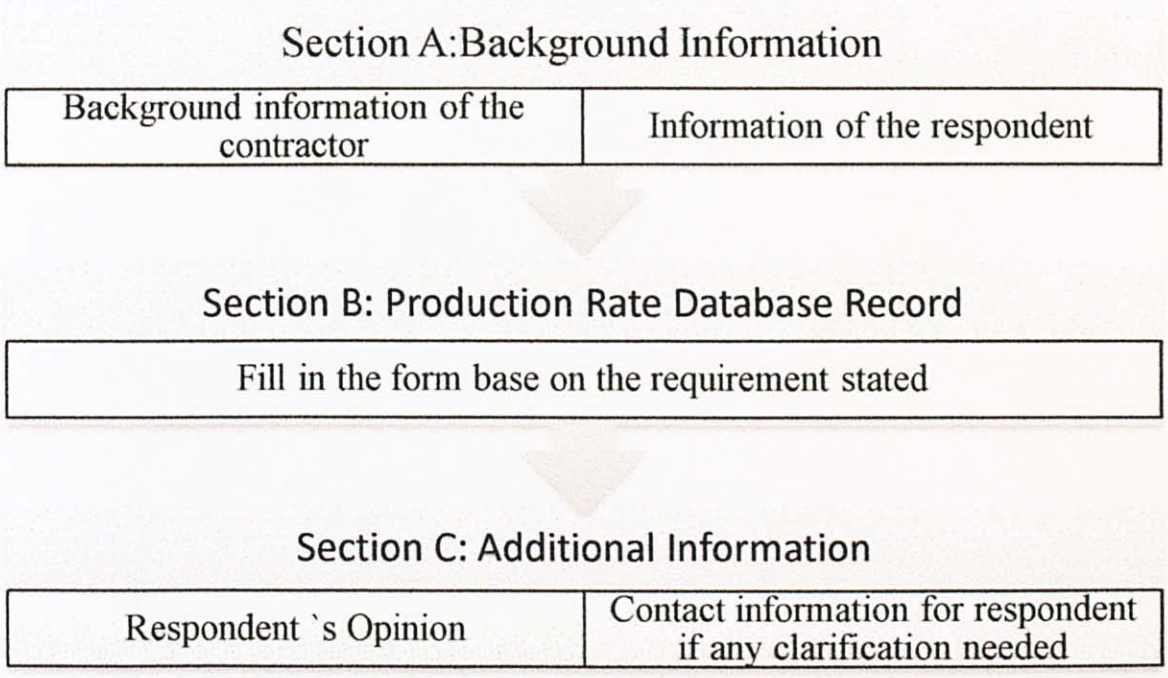

Figure 3.1:Layout of the questionnaire

3.5 Sample Survey and Distribution of Questionnaire

One of the process to choose a limited number of units from a group of a certain organization. By choosing a sample of survey, it is a vital process to make sure the study will become more efficient. Saris and Gallhofer (2007) stated that, sampling should be prepared in such a way that surveyor has no influence to the selected respondent. For respondent, normally to be pickup by random, but for a better result, a certain class of contractor will be taken for easy analysis. The sample survey for this study will be select from the list obtained from the Construction Industry Development Board (CIDB) Malaysia and the chosen group of contractor only from G5 to G7 class contractors will be select.

CHAPTER FOUR

RESULT AND DISCUSSION

The preferable procedure is to select the respondents at random but for a better result, a specific class of contractors will be chosen which can represent as Sample Size. The sample survey for this research was selected from the list obtained from the Construction Industry Development Board (CIDB) Malaysia and ranged only G5 to G7 class contractors was chosen. A total of 30 out of 300 respondents returned the questionnaire. Though representing only 10.0% of the original sample carried, this low percentage of response had been expected. The amounts of return questionnaire bypass the minimum requirement of 30 respondents in order to perform the descriptive analysis.

4.1 Description of Results

For the section on General/Background information about the respondents, data collected are presented in Tables 1 until Table 5 and descriptive analyses of these data depicted in the corresponding pie charts. For collected data questionnaire, they are presented as "raw data" in Table 6.

4.1.1 Respondent's of CIDB Registration

Table 1 and Figure 1 illustrate respondents' class of registration with CIDB respectively.

Table 4.1: Respondent's CIDB Class:

CIDB Class	No. of respondent
G5	14
G6	10
G7	6

The most highest Respondent`s CIDB Class is under G5 with 47% compare to other respondent`s CIDB class. G6 carries no. of respondent of 10 while G7 carries 6 altogether.

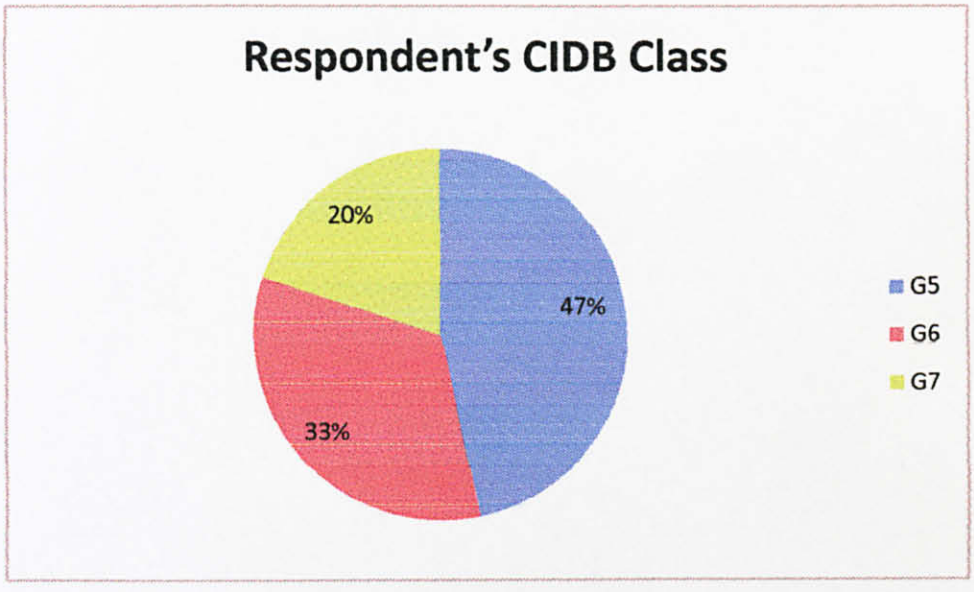

Figure 4.1: Respondent`s CIDB Class

4.1.2 Company`s main business

Table 2 and Figure 2 indicate Company`s main business respectively. Main Businesses are Building Projects, Road Projects and Water works projects.

Table 4.2: Company`s main business

Type of Works	No. of Respondent
Building Projects	8
Road Projects	6
Building& Road Projects	11
Water Works Projects	0
Water& Road Projects	2
Others	3

The highest No. of Respondent is 11 which is Building& Road Projects compare to other Types of Works. This shows that the Companies having Both Building&Road Projects are common in Malaysia.

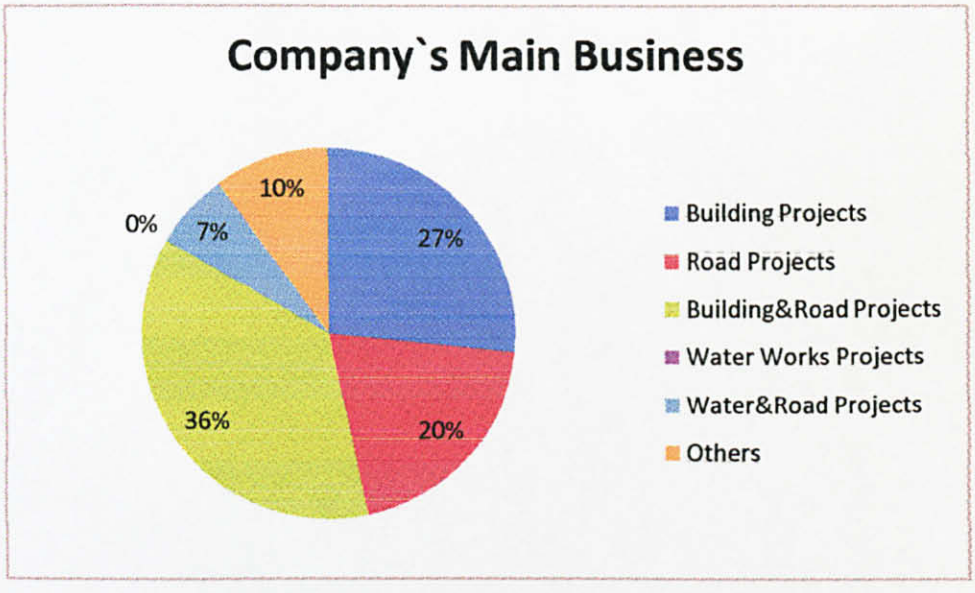

Figure 4.2: Company`s Main Business

4.1.3 Company`s Experience in Construction

Table 3 and Figure 3 represents the Company`s experience in building construction consists of 1-3years, 4-6years, 7-9years, 10-12years and more than 12years.

Table 4.3: Company`s Experience in Construction

Years	No. Of Respondents
1 --3	0
4--6	5
7--9	8
10--12	8
>12	9

The highest No. of Respondent is 9 carried by company`s experience more than 12 years. Compare to other Range of Years, they are not much different. This indicates that the companies which replied the questionnaire have sufficient knowledge and experience on building construction.

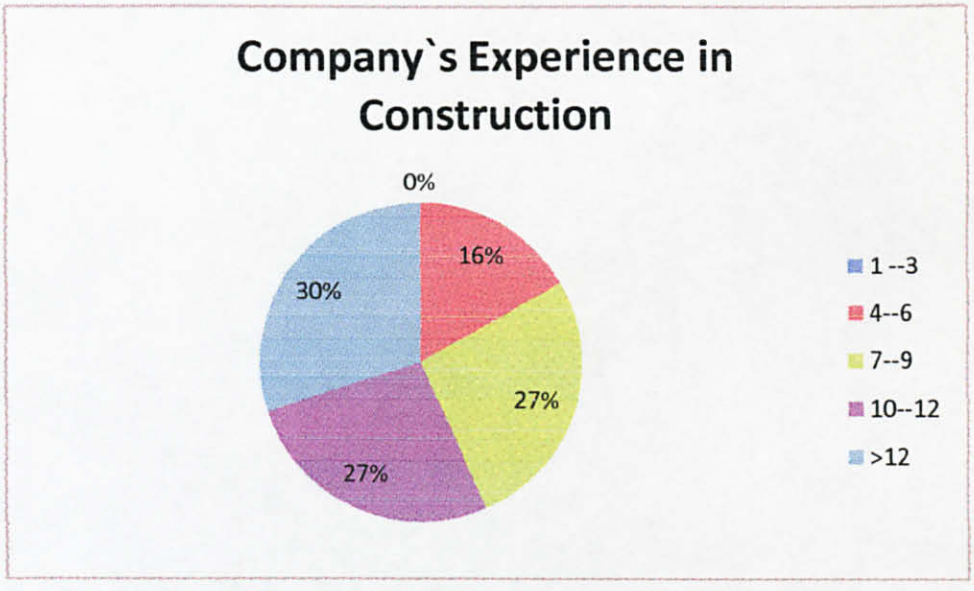

Figure 4.3: Company`s Experience in Construction

4.1.4 Respondent`s Designation

Respondent's designation with the company is indicated by Table 4 and Figure 4 below.

Table 4.4: Respondent`s Designation

Types Of Designation	No Of Respondent
Project Manager	4
Project Engineer	4
Construction Manager	10
Construction Superintendent	4
Planner	4
Other	4

From the table above, Respondent`s Designation of Construction Manager is the highest with 10 Respondent compare to other types of Designation.

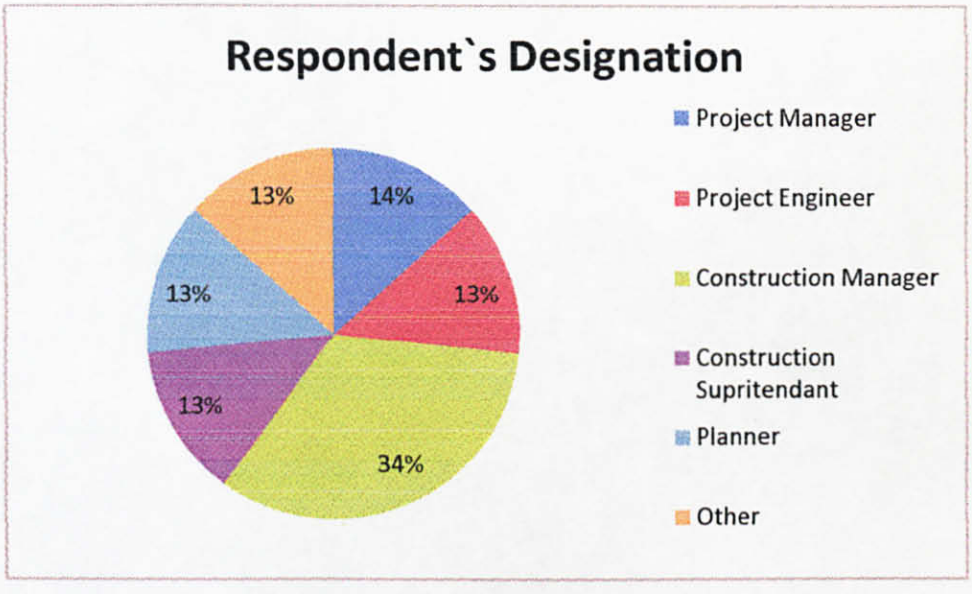

Figure 4.4: Respondent Designation

4.1.5 Respondent`s Experience

Table 5 and Figure 5 below shows the respondent`s experience in building construction.

Table 4.5: Respondent`s Experience

Experience(years)	No. Of Respondent
<5	4
5--10	14
11--15	9
16--20	3
20>	0

From the above table, Respondent`s experience of 5—10 years carried the highest number of respondent with 14 people compare to other respondent`s experience.

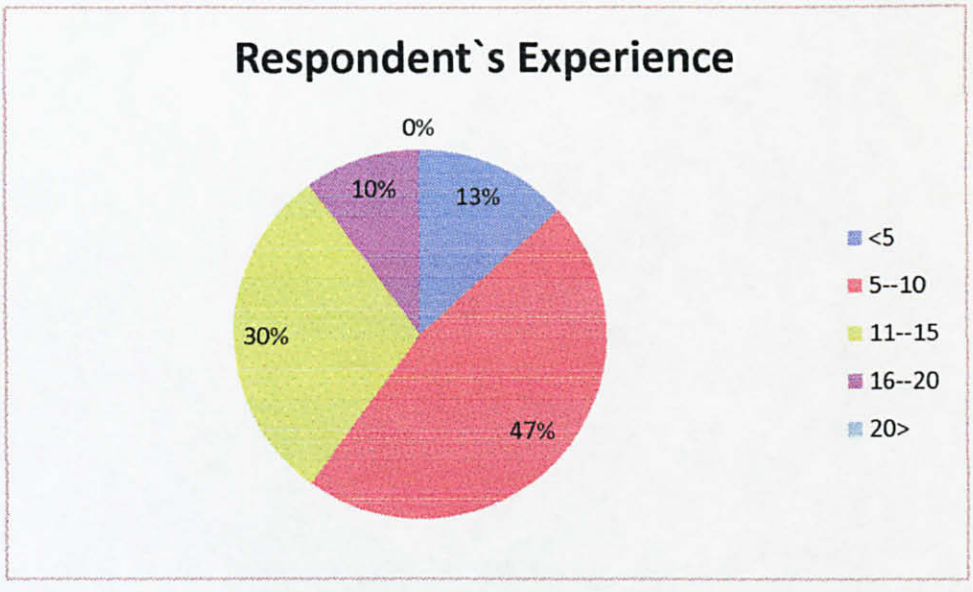

Figure 4.5: Respondent Experience

4.2 Production Rates: Presentation of Raw Data Collected

For data collection on Production Rate using Survey method, the data gathered are presented in "raw "data which means unanalyzed data in **Table 4.6**. These are measured base on 8 hours working days and the production rates were collected in days. During the data collection, eight set of data were obtained from questionnaire distribution, twelve set from email, four set of data were coming from personal interview and lastly six data were collected from phone interview. However, two set of data from the questionnaires could not be shown, instead of giving production rates, only gave machineries and number of workers used.

4.3 Production Rates: Analysis of the Data

Throughout the survey, the total of 30 questionnaires were collected and analyzed. For this type of analysis, descriptive analysis is the most suitable to be used. This is because it involves Variance Analysis, Mean and Mode Analysis. Variance Analysis is use to analyze in differences of production rate values based on respondents` experience. From the raw data produced, Mean and Variance Analysis and Variance values are calculated.

From the **Table 4.7**, a respective observation can be made on the pattern of differences in production rate base on respondents` experience. This can be told that the differences in production rate not varied much between each other. This is shown that respondents nowadays having better understanding on the production rates of certain activities.

Table 4.6 :Production Rate Raw Data

Activty/Task	Unit	Production rate														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Piling-Spun Piles including																
a)Setting Out	point/day	40	Na	20	30	28	43	40	30	30	NA	NA	38	30	30	30
b)Pile Driven	Num/day	10	7	10	3	16	12	15	9	6	12	8	13	8	4	4
c)Average Depth	m/day	230	210	200	230	250	242	247	210	290	235	270	265	293	249	290
d)Pile Cutting	point/day	50	28	50	20	25	40	59	27	22	45	25	60	21	20	25
Piling-Rc Piles including																
a)Setting Out	point/day	50	22	40	30	26	40	45	30	41	30	NA	42	30	30	30
b)Pile Driven	Num/day	15	32	10	11	17	11	16	15	17	20	27	17	10	25	25
c)Average Depth	m/day	200	250	278	269	290	210	225	235	245	200	215	264	240	280	211
d)Pile Cutting	point/day	50	12	45	25	25	51	56	27	28	21	20	57	24	22	24
Piling-Bored Piles(cast in place)																
a)Setting Out	point/day	NA	20	5	30	30	NA	NA	30	30	30	NA	25	30	30	30
b)Reinforcement Cage	Tonnes	NA	7	11	5	5	NA	NA	5	6	6	7	3	4	8	8
c)Average Depth	m/day	NA	40	2	15	15	NA	NA	15	45	50	68	10	16	75	75
d)Pile cutting	point/day	NA	3	10	Na	Na	NA	NA	NA	4	3	4	2	NA	3	3
Pile testing(Load Test)																
a)Pile Testing Setup	hour	5	8	5	5	8	10	12	4	6	8	16	10	4	14	14
b)Testing	hour	36	16	36	8	5	32	38	8	7	16	16	24	8	8	8
c)Dismantling Load and Beam	hour	4	5	4	5	7	10	9	4	6	5	16	7	12	16	16
Stump including																
a)Formwork Installation	m^2/day	50	62	50	40	150	81	72	41	53	60	55	75	55	73	61
b)Reinforcement Installation	tonnes/day	5	10	3	11	8	10	12	10	4	8	10	10	9	4	4
c)Concrete Works	m^3/day	55	65	57	60	65	60	78	52	30	80	30	35	65	40	50
d)Dismantle Formwork	m^2/day	120	170	154	150	150	120	125	135	158	130	110	100	120	100	120

Table 4.6 :Production Rate Raw Data

Activty/Task	Unit	Production rate														
		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Piling-Spun Piles including																
a)Setting Out	point/day	20	25	Na	NA	35	NA	NA	20	30	40	40	35	30	25	42
b)Pile Driven	Num/day	17	15	10	8	7	6	9	14	15	18	19	13	10	12	18
c)Average Depth	m/day	210	240	211	258	267	230	245	287	240	200	205	210	245	260	276
d)Pile Cutting	point/day	25	30	35	20	13	20	23	45	40	30	45	52	76	65	62
Piling-Rc Piles including																
a)Setting Out	point/day	25	25	NA	NA	35	NA	NA	30	40	40	40	35	30	25	48
b)Pile Driven	Num/day	14	15	18	10	10	24	17	24	17	19	24	13	24	30	18
c)Average Depth	m/day	245	231	200	276	289	256	276	217	266	231	279	261	278	222	243
d)Pile Cutting	point/day	21	27	38	32	24	27	30	20	40	50	58	80	62	73	58
Piling-Bored Piles(cast in place)																
a)Setting Out	point/day	30	25	NA	30	32	NA	30	NA	NA	35	40	30	30	25	20
b)Reinforcement Cage	Tonnes	5	5	5	5	6	7	7	7	8	5	6	3	5	5	4
c)Average Depth	m/day	15	14	65	16	45	70	20	70	75	13	57	20	16	60	13
d)Pile cutting	point/day	Na	3	3	3	3	3	3	3	4	NA	3	NA	NA	5	NA
Pile testing(Load Test)																
a)Pile Testing Setup	hour	8	6	16	5	6	16	6	16	6	5	4	5	5	18	14
b)Testing	hour	5	8	8	8	8	8	8	8	24	8	8	8	6	8	24
c)Dismantling Load and Beam	hour	7	6	16	5	6	16	5	16	4	4	4	5	10	18	10
Stump including																
a)Formwork Installation	m^2/day	60	55	72	100	67	87	65	123	74	95	55	45	50	100	72
b)Reinforcement Installation	tonnes/day	12	6	4	5	3	12	4	5	5	10	4	3	9	5	7
c)Concrete Works	m^3/day	65	70	54	40	35	30	55	30	35	54	100	110	55	60	73
d)Dismantle Formwork	m^2/day	120	140	130	154	137	187	192	200	210	125	131	146	165	190	173

Table 4.6 :Production Rate Raw Data

Activty/Task	Unit	Production rate														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Pad Footing including																
a)Excavation Works	m^3/day	100	120	150	115	145	115	150	101	129	154	124	160	140	151	80
b)Formwork Installation	m^2/day	115	65	100	67	57	119	118	41	67	115	70	130	50	125	80
c)Reinforment Installation	tonnes/day	8	10	7	12	14	15	16	8	9	7	6	15	8	3	3
d)Concrete Works	m^3/day	80	62	90	50	52	110	112	63	85	60	85	110	65	85	85
e)Dismantle Formwork	m^2/day	150	120	155	115	128	180	190	120	155	168	179	112	115	120	178
Strip Footing including																
a)Excavation Works	m^3/day	90	115	120	110	130	150	153	105	120	125	170	155	120	158	155
b)Formwork Installation	m^2/day	120	42	110	50	55	112	140	65	70	70	110	165	100	60	125
c)Reinforment Installation	tonnes/day	6	12	5	14	13	15	11	8	4	12	10	11	8	4	5
d)Concrete Works	m^3/day	60	68	80	60	47	50	127	49	40	60	85	125	60	82	82
e)Dismantle Formwork	m^2/day	200	100	180	120	128	130	180	175	160	120	140	178	150	120	186
Raft Footing including																
a)Excavation Works	m^3/day	140	90	100	120	115	153	120	42	110	127	156	125	131	160	155
b)Formwork Installation	m^2/day	80	55	61	110	70	75	89	51	138	120	50	130	70	85	80
c)Reinforment Installation	tonnes/day	15	15	10	8	15	13	14	14	6	11	16	9	15	24	24
d)Concrete Works	m^3/day	55	90	110	60	61	90	100	57	85	65	80	120	55	85	85
e)Dismantle Formwork	m^2/day	120	155	134	129	150	200	180	175	120	145	156	171	135	185	100
Pile Cap including																
a)Excavation Works	m^3/day	80	90	70	92	124	112	157	134	100	76	80	97	160	140	135
b)Formwork Installation	m^2/day	100	60	120	50	47	153	103	37	70	70	50	120	80	50	60
c)Reinforment Installation	tonnes/day	7	15	10	15	6	12	15	14	10	13	5	12	14	4.5	5
d)Concrete Works	m^3/day	80	75	40	60	75	105	110	47	71	80	80	115	35	85	85
e)Dismantle Formwork	m^2/day	150	100	180	50	80	160	185	58	120	98	97	170	98	90	120
Ground Beam including																
a)Formwork Installation	m^2/day	75	55	80	50	40	60	70	51	50	50	30	80	45	60	50
b)Reinforcement Installation	tonnes/day	10	22	15	18	13	15	14	15	15	20	16	15	16	16	16
c)Concrete Works	m^3/day	70	60	80	55	50	100	105	63	60	70	110	115	55	80	60
d)Dismantle Formwork	m^2/day	100	150	120	95	98	130	190	145	135	120	165	150	185	175	140

Table 4.6 :Production Rate Raw Data

Activty/Task	Unit	Production rate														
		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Pad Footing including																
a)Excavation Works	m^3/day	122	135	142	129	105	110	140	149	150	160	123	134	138	160	122
b)Formwork Installation	m^2/day	85	90	95	78	61	78	115	70	118	95	100	85	105	95	90
c)Reinforment Installation	tonnes/day	11	9	3	9	5	14	3	16	15	5	16	9	15	5	17
d)Concrete Works	m^3/day	52	60	81	60	85	80	80	70	80	80	80	80	60	72	90
e)Dismantle Formwork	m^2/day	120	135	90	95	120	129	170	120	130	150	145	127	131	190	190
Strip Footing including																
a)Excavation Works	m^3/day	98	100	155	105	90	115	127	120	135	150	160	121	135	145	155
b)Formwork Installation	m^2/day	65	70	44	48	48	48	55	60	87	69	55	50	58	70	130
c)Reinforment Installation	tonnes/day	12	4	4	6	6	4	5	14	17	8	12	4	16	6	9
d)Concrete Works	m^3/day	47	70	77	65	85	80	65	80	80	75	87	80	62	72	100
e)Dismantle Formwork	m^2/day	121	135	161	173	182	145	129	112	90	97	123	150	190	175	197
Raft Footing including																
a)Excavation Works	m^3/day	143	120	125	164	142	138	125	97	107	105	120	125	100	120	150
b)Formwork Installation	m^2/day	74	38	44	60	68	87	93	50	48	64	48	70	120	125	130
c)Reinforment Installation	tonnes/day	12	13	16	8	6.5	16	10	16	16	15	8	14	13	11	14
d)Concrete Works	m^3/day	61	65	80	70	85	80	70	46	80	70	80	70	60	72	121
e)Dismantle Formwork	m^2/day	105	110	94	95	105	96	118	195	135	154	145	125	120	95	181
Pile Cap including																
a)Excavation Works	m^3/day	70	50	85	70	60	89	80	35	70	83	70	60	100	72	157
b)Formwork Installation	m^2/day	47	55	50	57	70	48	51	58	53	45	75	70	63	60	104
c)Reinforment Installation	tonnes/day	6	14	5	8	12	14	8	6	10	16	8	13	14	5	15
d)Concrete Works	m^3/day	75	60	70	70	76	80	74	70	71	70	80	70	60	72	100
e)Dismantle Formwork	m^2/day	97	170	90	110	90	96	110	143	165	180	132	105	96	156	175
Ground Beam including																
a)Formwork Installation	m^2/day	40	45	35	60	50	30	55	25	54	45	51	35	55	40	100
b)Reinforcement Installation	tonnes/day	13	16	15	10	15	15	11	13	10	20	15	10	18	16	14
c)Concrete Works	m^3/day	50	60	95	70	60	63	55	50	100	65	60	60	50	40	116
d)Dismantle Formwork	m^2/day	100	125	165	90	185	190	125	138	147	190	200	101	191	167	156

Table 4.7 :Production Rate Raw Data (Based on Experience)

Activty/Task	Unit	Production rate(Base on Respondent`s Experience in years)														
		Less than 5					5 -- 10									
Piling-Spun Piles including																
a)Setting Out	point/day	Na	30	40	20	NA	30	Na	25	25	42	43	20	NA	35	NA
b)Pile Driven	Num/day	7	3	15	17	6	4	10	12	15	18	12	14	12	13	8
c)Average Depth	m/day	210	230	247	210	230	249	211	260	240	276	242	287	235	210	270
d)Pile Cutting	point/day	28	20	59	25	20	20	35	65	30	62	40	45	45	52	25
Piling-Rc Piles including																
a)Setting Out	point/day	22	30	45	25	NA	30	NA	25	25	48	40	30	30	35	NA
b)Pile Driven	Num/day	32	11	16	14	24	25	18	30	15	18	11	24	20	13	27
c)Average Depth	m/day	250	269	225	245	256	280	200	222	231	243	210	217	200	261	215
d)Pile Cutting	point/day	12	25	56	21	27	22	38	73	27	58	51	20	21	80	20
Piling-Bored Piles(cast in place)																
a)Setting Out	point/day	20	30	NA	30	NA	30	NA	25	25	20	NA	NA	30	30	NA
b)Reinforcement Cage	Tonnes	7	5	NA	5	7	8	5	5	5	4	NA	7	6	3	7
c)Average Depth	m/day	40	15	NA	15	70	75	65	60	14	13	NA	70	50	20	68
d)Pile cutting	point/day	3	Na	NA	Na	3	3	3	5	3	NA	NA	3	3	NA	4
Pile testing(Load Test)																
a)Pile Testing Setup	hour	8	5	12	8	16	14	16	18	6	14	10	16	8	5	16
b)Testing	hour	16	8	38	5	8	8	8	8	8	24	32	8	16	8	16
c)Dismantling Load and Beam	hour	5	5	9	7	16	16	16	18	6	10	10	16	5	5	16
Stump including																
a)Formwork Installation	m^2/day	62	40	72	60	87	73	72	100	55	72	81	123	60	45	55
b)Reinforcement Installation	tonnes/day	10	11	12	12	12	4	4	5	6	7	10	5	8	3	10
c)Concrete Works	m^3/day	65	60	78	65	30	40	54	60	70	73	60	30	80	110	30
d)Dismantle Formwork	m^2/day	170	150	125	120	187	100	130	190	140	173	120	200	130	146	110

Table 4.7 :Production Rate Raw Data (Based on Experience)

Activty/Task	Unit	Production rate(Base on Respondent`s Experience in years)														
		Less than 5					5 -- 10									
Pad Footing including																
a)Excavation Works	m^3/day	120	115	150	122	110	151	142	160	135	122	115	149	154	134	124
b)Formwork Installation	m^2/day	65	67	118	85	78	125	95	95	90	90	119	70	115	85	70
c)Reinforment Installation	tonnes/day	10	12	16	11	14	3	3	5	9	17	15	16	7	9	6
d)Concrete Works	m^3/day	62	50	112	52	80	85	81	72	60	90	110	70	60	80	85
e)Dismantle Formwork	m^2/day	120	115	190	120	129	120	90	190	135	190	180	120	168	127	179
Strip Footing including																
a)Excavation Works	m^3/day	115	110	153	98	115	158	155	145	100	155	150	120	125	121	170
b)Formwork Installation	m^2/day	42	50	140	65	48	60	44	70	70	130	112	60	70	50	110
c)Reinforment Installation	tonnes/day	12	14	11	12	4	4	4	6	4	9	15	14	12	4	10
d)Concrete Works	m^3/day	68	60	127	47	80	82	77	72	70	100	50	80	60	80	85
e)Dismantle Formwork	m^2/day	100	120	180	121	145	120	161	175	135	197	130	112	120	150	140
Raft Footing including																
a)Excavation Works	m^3/day	90	120	120	143	138	160	125	120	120	150	153	97	127	125	156
b)Formwork Installation	m^2/day	55	110	89	74	87	85	44	125	38	130	75	50	120	70	50
c)Reinforment Installation	tonnes/day	15	8	14	12	16	24	16	11	13	14	13	16	11	14	16
d)Concrete Works	m^3/day	90	60	100	61	80	85	80	72	65	121	90	46	65	70	80
e)Dismantle Formwork	m^2/day	155	129	180	105	96	185	94	95	110	181	200	195	145	125	156
Pile Cap including																
a)Excavation Works	m^3/day	90	92	157	70	89	140	85	72	50	157	112	35	76	60	80
b)Formwork Installation	m^2/day	60	50	103	47	48	50	50	60	55	104	153	58	70	70	50
c)Reinforment Installation	tonnes/day	15	15	15	6	14	4.5	5	5	14	15	12	6	13	13	5
d)Concrete Works	m^3/day	75	60	110	75	80	85	70	72	60	100	105	70	80	70	80
e)Dismantle Formwork	m^2/day	100	50	185	97	96	90	90	156	170	175	160	143	98	105	97
Ground Beam including																
a)Formwork Installation	m^2/day	55	50	70	40	30	60	35	40	45	100	60	25	50	35	30
b)Reinforcement Installation	tonnes/day	22	18	14	13	15	16	15	16	16	14	15	13	20	10	16
c)Concrete Works	m^3/day	60	55	105	50	63	80	95	40	60	116	100	50	70	60	110
d)Dismantle Formwork	m^2/day	150	95	190	100	190	175	165	167	125	156	130	138	120	101	165

Table 4.7 :Production Rate Raw Data (Based on Experience)

Activty/Task	Unit	Production rate(Base on Respondent`s Experience in years)														
		11--15										More than 15				
Piling-Spun Piles including																
a)Setting Out	point/day	40	30	30	30	35	28	NA	30	40	38	40	30	30	20	NA
b)Pile Driven	Num/day	18	6	8	4	7	16	8	15	10	13	18	10	9	10	9
c)Average Depth	m/day	200	290	293	290	267	250	258	240	230	265	200	245	210	200	245
d)Pile Cutting	point/day	30	22	21	25	13	25	20	40	50	60	30	76	27	50	23
Piling-Rc Piles including																
a)Setting Out	point/day	40	41	30	30	35	26	NA	40	50	42	40	30	30	40	NA
b)Pile Driven	Num/day	19	17	10	25	10	17	10	17	15	17	19	24	15	10	17
c)Average Depth	m/day	231	245	240	211	289	290	276	266	200	264	231	278	235	278	276
d)Pile Cutting	point/day	50	28	24	24	24	25	32	40	50	57	50	62	27	45	30
Piling-Bored Piles(cast in place)																
a)Setting Out	point/day	35	30	30	30	32	30	30	NA	NA	25	35	30	30	5	30
b)Reinforcement Cage	Tonnes	5	6	4	8	6	5	5	8	NA	3	5	5	5	11	7
c)Average Depth	m/day	13	45	16	75	45	15	16	75	NA	10	13	16	15	2	20
d)Pile cutting	point/day	NA	4	NA	3	3	Na	3	4	NA	2	NA	NA	NA	10	3
Pile testing(Load Test)																
a)Pile Testing Setup	hour	5	6	4	14	6	8	5	6	5	10	5	5	4	5	6
b)Testing	hour	8	7	8	8	8	5	8	24	36	24	8	6	8	36	8
c)Dismantling Load and Beam	hour	4	6	12	16	6	7	5	4	4	7	4	10	4	4	5
Stump including																
a)Formwork Installation	m^2/day	95	53	55	61	67	150	100	74	50	75	95	50	41	50	65
b)Reinforcement Installation	tonnes/day	10	4	9	4	3	8	5	5	5	10	10	9	10	3	4
c)Concrete Works	m^3/day	54	30	65	50	35	65	40	35	55	35	54	55	52	57	55
d)Dismantle Formwork	m^2/day	125	158	120	120	137	150	154	210	120	100	125	165	135	154	192

Table 4.7 :Production Rate Raw Data (Based on Experience)

Activty/Task	Unit	Production rate(Base on Respondent`s Experience in years)														
		11--15										More than 15				
Pad Footing including																
a)Excavation Works	m^3/day	160	129	140	80	105	145	129	150	100	160	160	138	101	150	140
b)Formwork Installation	m^2/day	95	67	50	80	61	57	78	118	115	130	95	105	41	100	115
c)Reinforment Installation	tonnes/day	5	9	8	3	5	14	9	15	8	15	5	15	8	7	3
d)Concrete Works	m^3/day	80	85	65	85	85	52	60	80	80	110	80	60	63	90	80
e)Dismantle Formwork	m^2/day	150	155	115	178	120	128	95	130	150	112	150	131	120	155	170
Strip Footing including																
a)Excavation Works	m^3/day	150	120	120	155	90	130	105	135	90	155	150	135	105	120	127
b)Formwork Installation	m^2/day	69	70	100	125	48	55	48	87	120	165	69	58	65	110	55
c)Reinforment Installation	tonnes/day	8	4	8	5	6	13	6	17	6	11	8	16	8	5	5
d)Concrete Works	m^3/day	75	40	60	82	85	47	65	80	60	125	75	62	49	80	65
e)Dismantle Formwork	m^2/day	97	160	150	186	182	128	173	90	200	178	97	190	175	180	129
Raft Footing including																
a)Excavation Works	m^3/day	105	110	131	155	142	115	164	107	140	125	105	100	42	100	125
b)Formwork Installation	m^2/day	64	138	70	80	68	70	60	48	80	130	64	120	51	61	93
c)Reinforment Installation	tonnes/day	15	6	15	24	6.5	15	8	16	15	9	15	13	14	10	10
d)Concrete Works	m^3/day	70	85	55	85	85	61	70	80	55	120	70	60	57	110	70
e)Dismantle Formwork	m^2/day	154	120	135	100	105	150	95	135	120	171	154	120	175	134	118
Pile Cap including																
a)Excavation Works	m^3/day	83	100	160	135	60	124	70	70	80	97	83	100	134	70	80
b)Formwork Installation	m^2/day	45	70	80	60	70	47	57	53	100	120	45	63	37	120	51
c)Reinforment Installation	tonnes/day	16	10	14	5	12	6	8	10	7	12	16	14	14	10	8
d)Concrete Works	m^3/day	70	71	35	85	76	75	70	71	80	115	70	60	47	40	74
e)Dismantle Formwork	m^2/day	180	120	98	120	90	80	110	165	150	170	180	96	58	180	110
Ground Beam including																
a)Formwork Installation	m^2/day	45	50	45	50	50	40	60	54	75	80	45	55	51	80	55
b)Reinforcement Installation	tonnes/day	20	15	16	16	15	13	10	10	10	15	20	18	15	15	11
c)Concrete Works	m^3/day	65	60	55	60	60	50	70	100	70	115	65	50	63	80	55
d)Dismantle Formwork	m^2/day	190	135	185	140	185	98	90	147	100	150	190	191	145	120	125

Table 4.8 shows the Mean and Variance values. From the table, it is obvious that there is a large variation among the data; hence the mean cannot be taken as the measure of central tendency. However, there are some values which occur more often in the raw data and Mode of the data was taken to represent the average data.

Table 4.9 presents the maximum, minimum, standard deviation and Median range of values of production rates for each activity. Maximum and minimum value can be obtained by first ranging the data and then selecting the range that have the highest value in the particular raw data and also the lowest value of the data. The reason using range as the value of end product of the analysis because of the data`s variance is very high. Single value of the result cannot be extract due to high variance value. It can be observed that the range of production value for is very huge for Pile testing (Load test) for testing, piling RC piles, setting out for piling and Piling-Spun piles in which the different of maximum and minimum value can be as 87%,85%,88% and 84%. **Table 4.10** shows the production rates database for substructure works. This database is based on range value throughout the activity involved.

Table 4.8 :Production Rate:Mean, Variance,production rate,%different between Max and Min

Activty/Task	Unit	Total 30 questionnaire			% Different Between Max and Min
		Mean	Variance	Production Rate	
Pad Footing including					
a)Excavation Works	m^3/day	132	410	160-80	50
b)Formwork Installation	m^2/day	89	567	130-41	68
c)Reinforcement Installation	tonnes/day	10	21	17-3	82
d)Concrete Works	m^3/day	77	273	112-50	55
e)Dismantle Formwork	m^2/day	141	828	190-90	53
Strip Footing including					
a)Excavation Works	m^3/day	130	521	170-90	47
b)Formwork Installation	m^2/day	78	1099	165-42	75
c)Reinforcement Installation	tonnes/day	9	17	17-4	76
d)Concrete Works	m^3/day	73	406	127-40	69
e)Dismantle Formwork	m^2/day	148	1014	200-90	55
Raft Footing including					
a)Excavation Works	m^3/day	124	633	164-42	74
b)Formwork Installation	m^2/day	79	852	130-38	72
c)Reinforcement Installation	tonnes/day	13	18	24-6	75
d)Concrete Works	m^3/day	77	344	121-46	62
e)Dismantle Formwork	m^2/day	138	1032	200-94	53
Pile Cap including					
a)Excavation Works	m^3/day	93	1077	160-35	78
b)Formwork Installation	m^2/day	69	743	153-37	76
c)Reinforcement Installation	tonnes/day	10	15	16-4.5	72
d)Concrete Works	m^3/day	75	315	115-35	70
e)Dismantle Formwork	m^2/day	122	1477	185-50	73
Ground Beam including					
a)Formwork Installation	m^2/day	52	270	100-25	75
b)Reinforcement Installation	tonnes/day	15	9	22-10	55
c)Concrete Works	m^3/day	71	468	116-40	66
d)Dismantle Formwork	m^2/day	146	1136	200-90	55

Table 4.8 :Production Rate:Mean, Variance,production rate,%different between Max and Min

Activty/Task	Unit	Total 30 questionnaire			% Different
		Mean	Variance	Production Rate	Between Max and Min
Piling-Spun Piles including					
a)Setting Out	point/day	32	50	43-20	53
b)Pile Driven	Num/day	11	20	19-3	84
c)Average Depth	m/day	243	809	293-200	32
d)Pile Cutting	point/day	37	275	76-13	83
Piling-Rc Piles including					
a)Setting Out	point/day	34	60	50-22	56
b)Pile Driven	Num/day	18	38	32-10	69
c)Average Depth	m/day	246	820	290-200	31
d)Pile Cutting	point/day	38	317	80-12	85
Piling-Bored Piles(cast in place)					
a)Setting Out	point/day	28	45	40-5	88
b)Reinforcement Cage	Tonnes	6	3	11--3	73
c)Average Depth	m/day	37	652	75-25	67
d)Pile cutting	point/day	4	3	10--2	80
Pile testing(Load Test)					
a)Pile Testing Setup	hour	9	21	18-4	78
b)Testing	hour	14	104	38-5	87
c)Dismantling Load and Beam	hour	9	23	18-4	78
Stump including					
a)Formwork Installation	m^2/day	70	594	150-40	73
b)Reinforcement Installation	tonnes/day	7	10	12--3	75
c)Concrete Works	m^3/day	56	392	110-30	73
d)Dismantle Formwork	m^2/day	145	878	210-100	52

Activty/Task	Maximum	Minimum	Standard Deviation	Median
Piling-Spun Piles including				
a)Setting Out	43	20	7.10	30
b)Pile Driven	19	3	4.45	10
c)Average Depth	293	200	28.45	243.5
d)Pile Cutting	76	13	16.59	30
Piling-Rc Piles including				
a)Setting Out	50	22	7.76	30
b)Pile Driven	32	10	6.15	17
c)Average Depth	290	200	28.63	245
d)Pile Cutting	80	12	17.81	29
Piling-Bored Piles(cast in place)				
a)Setting Out	40	5	6.71	30
b)Reinforcement Cage	11	3	1.73	5
c)Average Depth	75	25	25.54	20
d)Pile cutting	10	2	1.72	3
Pile testing(Load Test)				
a)Pile Testing Setup	18	4	4.54	7
b)Testing	38	5	10.22	8
c)Dismantling Load and Beam	18	4	4.80	6.5
Stump including				
a)Formwork Installation	150	40	24.38	63.5
b)Reinforcement Installation	12	3	3.10	6.5
c)Concrete Works	110	30	19.80	55
d)Dismantle Formwork	210	100	29.64	138.5

Table 4.9 :Production Rate :Minimum,Maximum,Standard Deviation and Median

Activty/Task	Maximum	Minimum	Standard Deviation	Median
Pad Footing including				
a)Excavation Works	160	80	20.25	135
b)Formwork Installation	130	41	23.81	90
c)Reinforcement Installation	17	3	4.60	9
d)Concrete Works	112	50	16.52	80
e)Dismantle Formwork	190	90	28.77	131
Strip Footing including				
a)Excavation Works	170	90	22.83	126
b)Formwork Installation	165	42	33.16	67
c)Reinforcement Installation	17	4	4.14	8
d)Concrete Works	127	40	20.14	74
e)Dismantle Formwork	200	90	31.85	148
Raft Footing including				
a)Excavation Works	164	42	25.16	125
b)Formwork Installation	138	38	29.18	72
c)Reinforcement Installation	24	6	4.23	14
d)Concrete Works	121	46	18.54	76
e)Dismantle Formwork	200	94	32.13	135
Pile Cap including				
a)Excavation Works	160	35	32.82	84
b)Formwork Installation	153	37	27.25	60
c)Reinforcement Installation	16	4.5	3.90	11
d)Concrete Works	115	35	17.74	75
e)Dismantle Formwork	185	50	38.43	110
Ground Beam including				
a)Formwork Installation	100	25	16.42	50
b)Reinforcement Installation	22	10	2.95	15
c)Concrete Works	116	40	21.63	62
d)Dismantle Formwork	200	90	33.70	146

Page 28 d)

Table 4.9 :Production Rate :Minimum,Maximum,Standard Deviation and Median

Page 29 e)

Activty/Task	Unit	Production Rate
Piling-Spun Piles including		
a)Setting Out	point/day	43-20
b)Pile Driven	Num/day	19-3
c)Average Depth	m/day	293-200
d)Pile Cutting	point/day	76-13
Piling-Rc Piles including		
a)Setting Out	point/day	50-22
b)Pile Driven	Num/day	32-10
c)Average Depth	m/day	290-200
d)Pile Cutting	point/day	80-12
Piling-Bored Piles(cast in place)		
a)Setting Out	point/day	40-5
b)Reinforcement Cage	Tonnes	11--3
c)Average Depth	m/day	75-25
d)Pile cutting	point/day	10--2
Pile testing(Load Test)		
a)Pile Testing Setup	hour	18-4
b)Testing	hour	38-5
c)Dismantling Load and Beam	hour	18-4
Stump including		
a)Formwork Installation	m^2/day	150-40
b)Reinforcement Installation	tonnes/day	12--3
c)Concrete Works	m^3/day	110-30
d)Dismantle Formwork	m^2/day	210-100

Page 29 e)

Activty/Task	Unit	Production Rate
Pad Footing including		
a)Excavation Works	m^3/day	160-80
b)Formwork Installation	m^2/day	130-41
c)Reinforment Installation	tonnes/day	17-3
d)Concrete Works	m^3/day	112-50
e)Dismantle Formwork	m^2/day	190-90
Strip Footing including		
a)Excavation Works	m^3/day	170-90
b)Formwork Installation	m^2/day	165-42
c)Reinforment Installation	tonnes/day	17-4
d)Concrete Works	m^3/day	127-40
e)Dismantle Formwork	m^2/day	200-90
Raft Footing including		
a)Excavation Works	m^3/day	164-42
b)Formwork Installation	m^2/day	130-38
c)Reinforment Installation	tonnes/day	24-6
d)Concrete Works	m^3/day	121-46
e)Dismantle Formwork	m^2/day	200-94
Pile Cap including		
a)Excavation Works	m^3/day	160-35
b)Formwork Installation	m^2/day	153-37
c)Reinforment Installation	tonnes/day	16-4.5
d)Concrete Works	m^3/day	115-35
e)Dismantle Formwork	m^2/day	185-50
Ground Beam including		
a)Formwork Installation	m^2/day	100-25
b)Reinforcement Installation	tonnes/day	22-10
c)Concrete Works	m^3/day	116-40
d)Dismantle Formwork	m^2/day	200-90

Table 4.10 : production rates database for substructure works

4.4 Insufficient Respondent

Every steps and consideration already taken to ensure that the questions asked in the questionnaire were short, simple and direct to the points. A cover letter was also attached with the questionnaire to highlight the importance of this study towards the construction industry in Malaysia. Stamped envelopes were also attached so that the respondents just mail the answered questionnaire without using their money. Through follow-up calls and also extension time given, only 30 out of 300 samples were collected. Since that only 8 respondents received through mailing, other survey method had already carry on. Other survey methods used were through phone interview carried 7 respondents, Email by 12 respondents and personal Interview was 3 respondents. Even though the minimum data should be at least 30 to start the analysis, it is still consider low respond. This is might due to:

a) Some respondents answering this questionnaire with critical thinking about the production rate like estimation of works. This required more effort and time. This can de-motivated them for answering.
b) Only high level and experience people can give some opinions about the production rates. Only companies which already involved a lot of projects can be able to respond to this questionnaire. The lack of these might have hindered response.
c) It is a mind set of people. In nowadays phenomena, people or respondents are hard to give something that are not brings any benefits to them or any interest. This can also contribute to the low respond of questionnaire.

4.5 Variability of the result

As prepared in **Table 4.8**, the variation between minimum and maximum of production rate can be highly as 88%, 87%, 85% and 84% such as in Setting Out for Piling-Bored piles, Pile Cutting for Piling-Rc Piles, Pile Testing and Pile driven for piling-Spun Piles. This huge variability of data due to:-

a) Respondents think of different machineries, type of soil or method used for some activity. They might think these in bigger perspective and it is hard to find the exact production rates due to more of factors that needs to be consider. All kind of factors will affect the production rate.

b) Some respondents misunderstanding about units. The questionnaire asked in unit/day and not unit/hour. This makes the author confuse about the units and needs to take extra time to convert back to unit/day. Some of respondent gave illogical production rates but it is still taken as the data collected.

c) Different of views and perception carried by the respondent as how fast for a certain activity can be achieved. For some reason, some respondent misunderstood about this production rate. It should be how quick a certain work can be done. A part of them answers the common production rate use to use.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

Production rate is very important towards the completion of a project in time and also the planning of certain works should be well organized. Despite of facing a lot of obstacles during the commencement of the project for example like final problem and time constraints, the research has successfully achieved those objectives which are to collect data on production rates from the industries, to analyze data collected using statistics and to develop a database of substructure works production rates works. Also need to know that these production rate values could not easily accepted for construction use because of they are only focus on a small sample of data. The variability of the data is also huge but this can put as indication of the characteristics of construction works` production rates in Malaysia and somehow this can be used as the basis for development especially towards people who having no ideas upon the production rates to be used for certain activity. Graduates students can make this production rate database as their reference as well since they don't have working experience.

The next step for the authors` is to continue the research with more bigger area covered in future. Since that the respondents mostly comes from Peninsular Malaysia, the further research will be other region of Malaysia including Sabah and Sarawak. For further study, a complete range of construction work shall include also the architectural works, highway construction and also Industrialized Building System construction. For the methodology, the survey method will be conducted not only face- to- face interview throughout experience construction managers, but also directly towards people who are in charge in daily construction meaning to say is to the site people. Through face-to-face interview, more information and explanation to production rates can be produce in way that given the respondent in interactive ways. Lastly, to enhance the accuracy and reliability of the database developed, the data produce should be compare to ongoing real projects so that the database for production rate can be updated from time to time. All the information and techniques use are aim to achieve the optimum goal of the research. Meaning to say, this database can be easily accessible throughout the construction industry in Malaysia.

CHAPTER 6
ECONOMIC BENEFITS

Under this chapter, the author had spent a lot amount of money in order to ensure the project will be completed on time. For this project, the total cost of RM501.20 already spent towards the completion of project. This can be break down into several components of purchasing. First is the purchasing of 0.40cent stamps with the total of 625 pieces altogether. It is worth of RM250. The purpose of the stamps is to mail the questionnaire to the respective companies for production rate data collection. Next is the bus ticket from Kota Bharu to Kuala Terengganu return ticket worth RM14.40 and RM14.30 altogether. The purpose is to achieve the data requisition through interview and also the same for return bus ticket from Kuala Terengganu to Lumut worth rm118.40. Lastly is the bus ticket from Lumut to Kota Bharu worth RM40.10. Also not forgetting the questionnaire that already photostat and expenditure of envelops worth of RM54.00. The rest of the cost like the consumption of fuel for data gathering process is not included since the author less using private vehicle to collect data and also interview. Plus, the stationery that needs to be use for sending the questionnaires like glue, papers for printing and also marker pen to jot down the address of the company on the envelops. They are worth of RM10. As the conclusion of this chapter, these are the total expenses spent starting from final year project one until final year project 2. By developing this database of Substructure works, contractors can ensure that they already planned well for their works and they can know their cost for certain activity depending on their production rate values.

REFERENCES

Azhar, S., and Ahmed, S. M. _2007_. "Development of a productivity information management system using data warehousing for construction organizations." *Proc., 2007 Construction Research Congress*, Freeport, Bahamas.

Abdul-Malak, M. A., Ei-Saadi, M. H., and Abou-Zeid, M. _2002_. "Process model for administrating construction claims." *J. Manage. Eng.*, 18(2)

Bubshait, A. A., and Cunningham, M. J. _1998_. "Comparison of delay analysis methodologies." *J. Constr. Eng. Manage.*, 124(4)

Thomas, H. R., Maloney, W. F., Smith, G. R., Sanders, S. R., Horner, R. M. W., and Handa, V. K. (1990). ''Productivity models for construction.'' *J. Constr. Engrg. and Mgmt.*, ASCE, 116(4),

Thomas, H. R., and Zavrs˘ki, I. (1998). ''The theoretical foundation for international labor productivity comparisons.'' *Rep. to the International Council for Building Reseach Studies and Documentation*, Rotterdam, The Netherlands.

Halpin, D. W., and Riggs, L. S. ~1992!. *Planning and analysis of construction operations*, Wiley, New York.

Peurifoy, R. L., Ledbetter, W. L., and Schexnayder, C. J. ~1996!. *Construction, planning, equipment, and methods*, 5th Ed., McGraw-Hill, New York.

Thomas, H. R., and Raynar, K. A. (1997). ''Scheduled overtime and labor productivity: quantitative analysis.'' *J. Constr. Engrg. and Mgmt.*,ASCE, 123(2)

Diekmann, J. E., and Thrush, K. B. _1986_. *Project control in design engineering*, University of Colorado Press, Boulder, Colo.

Saito, M., and Sinha, C. K. ~1989!. "The development of optimal strategies for maintenance, rehabilitation, and replacement of highway bridges: Priority ranking method." *FHWA/IN/JHRP-89/12*, Final Rep. Vol. 5.

Hajjar, D., AbouRizk, S. M., and Hunka, D. _1999_. "Improved project control through advanced data acquisition technologies." *Proc., 1999 Construction Specialty Conf.*, CSCE, Regina, Sask, Canada

Karshenas, S., and Feng, X. _1992_. "Application of neural networks in earthmoving equipment production estimating." *Proc., 8th Conf. Computing in Civil Engineering*, ASCE, New York

Zayed, T. M., and Halpin, D. W. _2005_. "Pile construction productivity assessment." *J. Constr. Eng. Manage.*,

Goodrum, P., and Haas, C. _2002_ "Partial factor productivity and equipment technology change at the activity level in the U.S. construction industry." *J. Constr. Eng. Manage.*, 128_6_

Koch, J., and Moavenzadeh, F. _1979_. "Productivity and technology in construction." *J. Constr. Div.*, 105_4_

Kossoris, M. (1944). "Studies of the effects of long working hours." *Bureau of Labor Statistics Bull. 791 and 791A,* Government Printing Office, Washington, D.C.

Thomas, H. R., and Mathews, C. T. "Methods of productivity measurement." *Report,* Construction Industry Institute, Austin, Tex.

Waldron, A. J. (1968). *Applied principles of project planning and control.* 2nd Ed., Haddonfleld, N.J.

Lewis, W. O., Curran, T. P., and Borcherding, J. D. (1985). "The effect of scheduled overtime on construction craft performance." *Summary Report,* Productivity Measurement Committee, Construction Industry Institute, Austin, Tex.

McLeish, D. C. A. (1981). "Manhours and interruptions in traditional house building." *Bldg. and Environ.,* 16(1)

Sanders, S. R., and Thomas, H. R. (1990). "Masonry conversion factors." *Masonry Soc. /.,* 9(1)

Thomas, H. R., Smith, G. R., Sanders, S. R., and Mannering, F. L. (1989b). "An exploratory study of productivity forecasting using the factor model for masonry." *PTI Report No. 9005,* Pennsylvania State Univ., Pennsylvania Transp. Inst., University Park, Pa., Dec.

Thomas, H. R. (1991). "Labor productivity and work sampling: The bottom line." */. Constr. Engrg. and Mgmt,* ASCE, 117(3)

Sanders, S. R., Thomas, H. R., and Smith, G. R. (1989). "An analysis of factors affecting labor productivity in masonry construction." *PTI Report No. 9003,* Pennsylvania State Univ., Pennsylvania Transp. Inst., University Park, Pa., Aug.

APPENDICES

UNIVERSITI
TEKNOLOGI
PETRONAS

To: Project Manager

Date: 16th September 2009

Dear Sir/Madam,

An Industry survey of production rate values for substructure works

We seek your help in a university research survey on production rates in civil engineering projects within the construction industry in Malaysia.

The construction industry is one of the industries that involved many uncertainties in its everyday operations. In construction, information on activity duration is important in scheduling construction activities on site, in costing the activities or predicting overall project completion time. Since that no specific calculation required to evaluate the production rate, their values are based on the experience and judgment of certain designation.

Therefore a need to elicit and compile such information from the industry, analyze to develop a formal database of "moderated" production rate, which is not only reliable but also accessible by everyone in the industry. This type of database is also useful to the new graduate students to know the production rates for certain activity. Since they do not have experience in working field, this production rate database is the best guideline for them.

In relation to the above, we have devised a questionnaire which we would like you to complete and return and which will only take no more than 15 minutes of your time. With your cooperation, we should be able to collect as many data as possible regarding the production rates in civil engineering project.

It would help us very much if you could complete and return the questionnaire attached by 9th November 2009. As an enclosure, please find a self-addressed and stamped envelope to return the questionnaire. Alternatively, you could also return it by fax on 05-3656716 (Attn: Assoc. Prof. Ir. Dr. Arazi Idrus).

Should you require any further information regarding this questionnaire, please do not hesitate to contact **Fariz Bin Adnan at 019-9534043** or email fariz.zck@gmail.com.

We thank you in advance for your support.

Yours truly,

_____

(Assoc. Prof. Ir. Dr. Arazi Idrus)
Associate Professor/Research Cluster Leader
Civil Engineering Department,
Universiti Teknologi PETRONAS

cc: Assoc. Prof. Dr. Shamsul Rahman Mohamed Kutty
Fariz Bin Adnan

SURVEY QUESTIONNAIRE

Development of a Database for Civil & Structural Construction Works` Production Rates

The purpose of this study is to conduct a research to develop a database for civil & structural works production rates. The database shall form a basis in predicting the behavior of Malaysian civil & structural works production rates .This result of the study can be accessible by everyone in the industry with a typical production rate. The database also can be use for the new graduate students to know the production rate for certain activity involves in the site construction. Since they do not have experience in working field, this is the best guidelines for them.

The questionnaire is divided into four sections. Those sections are Section A:General/Background Information , Section B:Production Rate Database Record , Section C: Production Rate Importance Factor and Section D:Additional Information. Please answer the questionnaire given for every sections. After completed, please mail back to the author by using the address given.

Section A : General/ Background Information

*Respondent can **Bold/put number 1** more than one for each [ ] provided or fill in the blanks.*

1) **Company details :**
   a) Name of the company : _____
   b) Class of Contractor:
      i) CIDB= [ ] G5 [ ]G6 [ ]G7

   c) Company's main business:

   [ ] Building projects [ ] Road projects[ ] Water works projects

   [ ] Other: _____

   Company's experience in building construction? _____Years

2) **Respondents**
   a) What is your designation with the company?
      [ ]Project Manager [ ]Construction Manager [ ]Planner
      [ ]Project Engineer [ ]Construction Superintendent [ ]Other:_____

   b) Respondent`s experience in building construction?

      [ ] < 5 [ ] 5-10 [ ] 11-15 [ ] 16-20 [ ] 20>

Section B:Production Rate Database Record

Please fill the value of production rate in the box provided. Also fill on how many workers and machineries used in a certain project. Write any additional information in Remarks section given. Assume the soil in flat area and leveled.

No	Activity	Common unit		Alternative Unit	Data							Remarks
					Number of Workers	Machineries used per day						
						Bh	C	V	Cm	Exc	Bm	
1												
	Piling Works											
	Drive of __mm **Spun pile**(Soil type:_____)											
	a) Setting out		Point/day									
	b) Pile driven		Nos									
	c) Average depth		m/day									
	d) Pile cutting		point/day									
	Drive of __mm **Rc piles**(Soil type:_____)											
	a) Setting out		Point/day									
	b)) Pile driven		Nos									
	c) Average depth		m/day									
	d) Pile cutting		Point/day									
	Bored piles cast-in-place(Soil type:_____)											
	a) Setting out		Point/day									
	b) Reinforcement Cage		Tonnes									
	c) Average depth		m									
	d) Pile cutting		Point/day									
	Pile testing(Load Test)											
	a)Pile testing setup		hour									
	b)Testing		hour									
	c)Dismantling load and beam		hour									
2	**~Shallow Foundation~**											
	Pad Footing including:											
	a) Excavation works		m^3/day									
	b)Cut and install formwork		m^2/day									
	c) Cut, bend and install reinforcement		tonnes/day									
	d)Concrete works		m^3/day									
	e)Dismantle formwork		m^2/day									
	Strip Footing including:											
	a) Excavation works		m^3/day									
	b)Cut and install formwork		m^2/day									
	c) Cut, bend and install reinforcement		tonnes/day									
	d)Concrete works		m^3/day									
	e)Dismantle formwork		m^2/day									
	Raft Footing including:											
	a) Excavation works		m^3/day									
	b)Cut and Install formwork		m^2/day									
	c) Cut, bend and install reinforcement		tonnes/day									
	d)Concrete works		m^3/day									
	e)Dismantle formwork		m^2/day									

Note; Average working hours=8 hours or please specify(___hours)

Bh=Backhoe C= Crane V= Vibrator Cm= Concrete Mixer Exc= Excavator Bm= Barbending Machine Alternative Unit=Other unit used beside common unit(if have)

No.	Activity	Common unit		Alternative Unit	Data						Remarks
					Number of Workers	Machineries used per day					
						Bh	C	V	Cm	Exc	Bm	
	Pile Cap including:											
	a) Excavation works		m^3/day									
	b)Cut and install formwork		m^2/day									
	c) Cut, bend and install reinforcement		tonnes/day									
	d)Concrete works		m^3/day									
	e)Dismantle formwork		m^2/day									
	Ground Beam including											
	a)Cut and install formwork		m^2/day									
	b)Cut, bend and install reinforcement		tonnes/day									
	c)Concrete works		m^3/day									
	d)Dismantle formwork		m^2/day									
	Stump including											
	a)Cut and install formwork		m^2/day									
	b)Cut, bend and install reinforcement		tonnes/day									
	c)Concrete works		m^3/day									
	d)Dismantle formwork		m^2/day									

Note; Average working hours=8 hours or please specify(___hours)
Bh=Backhoe C= Crane V= Vibrator Cm= Concrete Mixer Exc= Excavator Bm= Barbending Machine
Alternative Unit= Other unit used beside common unit(if have)

	Risk Factors	Building Construction			Road Construction		
a)	Safety/Accidents	1	2	3	1	2	3
b)	Labor, material and equipment availability	1	2	3	1	2	3
c)	Weather condition	1	2	3	1	2	3

Section C: Production Rate Importance Factors

For this section, please rate the production factors that might affect construction process by ticking/Bolding the appropriate number according to the priority scale given below. Please tick according to your company's main business:

[1] Less important [2] Important [3] Very importan

Section D : Additional Information

Please fill in the blanks and tick in the [ ] provided.

1. Where do you achieved the production rates values?

_____

2. What are the common problems face during construction project.

_____

3. Is there any additional information to help in the study?

_____

4. Would you willing to be contacted to provide additional information to support this research?

[ ] Yes.
My name is_____
My contact telephone number is_____ext:_____(office)
[ ] No

Thank you for your time and cooperation in completing the questionnaire. Your response will be used for research purpose only. It would be appreciated if you could return this questionnaire as soon as possible, if possible by **24 January 2010**.

No.	Detail/ Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Project Work Continue															
2	Submission of Progress Report 1															
3	Project Work Continue															
4	Submission of Progress Report 2															
5	Meeting with Supervisor															
5	Project work continue															
6	Poster Exhibition															
7	Submission of Dissertation (soft bound)															
8	Oral Presentation															
9	Submission of Project Dissertation (Hard Bound)															

Suggested milestone

Process

No.	Detail/ Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Selection of Project Topic															
2	Preliminary Research Work															
3	Submission of Preliminary Report															
4	Literature review															
5	Project Work															
6	Submission of Progress Report 1															
7	Submission of Progress Report 2															
8	Project work continues															
9	Submission of Interim Report Final Draft															
10	Oral Presentation															

Milestone

Process